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16. ABSTRACT

Traffic line striping has usually necessitated lane closures and traffic control to keep vehicles from tracking the fresh paint. To alleviate the safety hazards and time consuming coning and retrieving operation, California designed and built a fleet of hot stripers. These stripers heat traffic paint to around 200°F, and apply traffic paint stripes that dry to a no-track condition in 30 seconds or less. No cones or other traffic control devices are necessary.

To accomplish the 30-second no-track dry time, existing traffic paints had to be reformulated. This report describes the formulation of paints for use in these hot stripers as well as formulations for cold applied paints. It also describes the problems with bead retention in the rapid dry paint.

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION AND RESEARCH
TRANSPORTATION LABORATORY

September 1975

FHWA No. D-5-35
TL No. 635135

Mr. R. J. Datel
Chief Engineer

Dear Sir:

I have approved and now submit for your information this interim research project report titled:

DEVELOPMENT OF SPECIFICATIONS FOR
HOT AND COLD APPLIED TRAFFIC PAINTS

Study made by . . . . Concrete Branch

Under the Supervision of . . . . D. L. Spellman

Principal Investigator . . . . T. L. Shelly

Co-Investigator . . . . D. R. Chatto

Report Prepared by . . . . D. R. Chatto

Assisted by . . . . B. K. Beede and
B. J. Chapman

Very truly yours,

George A. Hill

GEORGE A. HILL
Chief, Office of Transportation Laboratory

Attachment

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Pervo Paint Company, Los Angeles, California
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J. E. Bauer Company, Los Angeles, California
Norris Paint and Varnish Co., Inc., Salem, Oregon
I.C.I. America Inc., Wilmington, Delaware
Hercules Incorporated, Los Angeles, California
Neville Chemical Company, Anaheim, California
Chevron Research Company, El Segundo, California
Reichhold Chemicals, Incorporated, Azusa, California
National Lead Industries, Oakland, California
Johns-Manville Products Corporation, San Francisco, California

We would also like to express appreciation for the cooperation and help received from J. D. Cross, Senior Maintenance Superintendent in Oakland, California, in the initial phases of the hot striper testing and evaluation.

Our appreciation is extended to Mr. F. J. Forte, Superintendent, Headquarters Equipment Shop, for the design and expedient fabrication of the small scale hot striper used for our paint testing program, and to Mr. G. Vanciel and Mr. T. Buckmaster for their help and ideas in assembly of this unit.

The contents of this report reflect the views of the Transportation Laboratory which is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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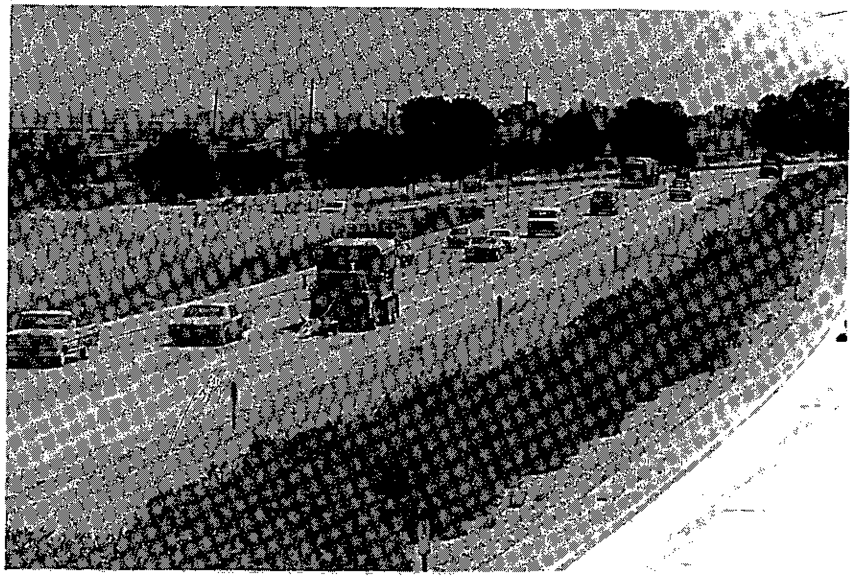
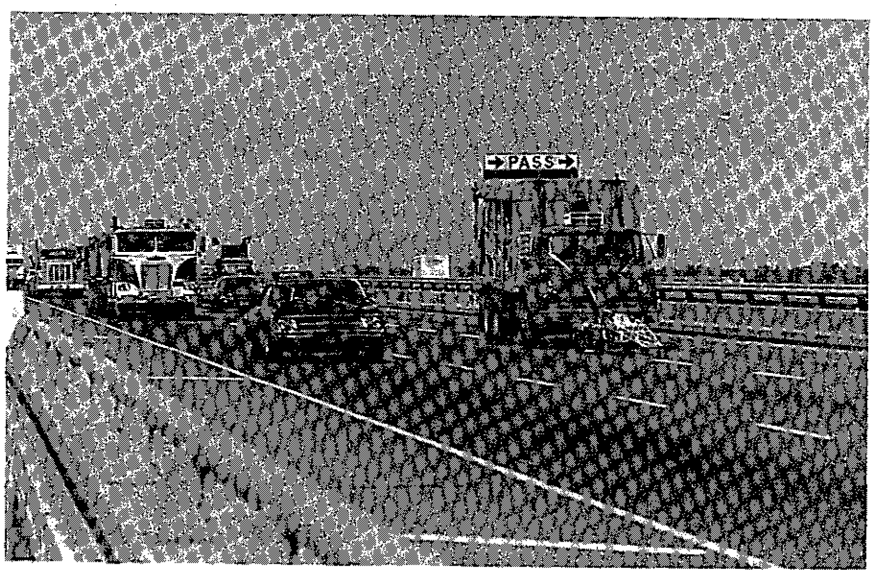
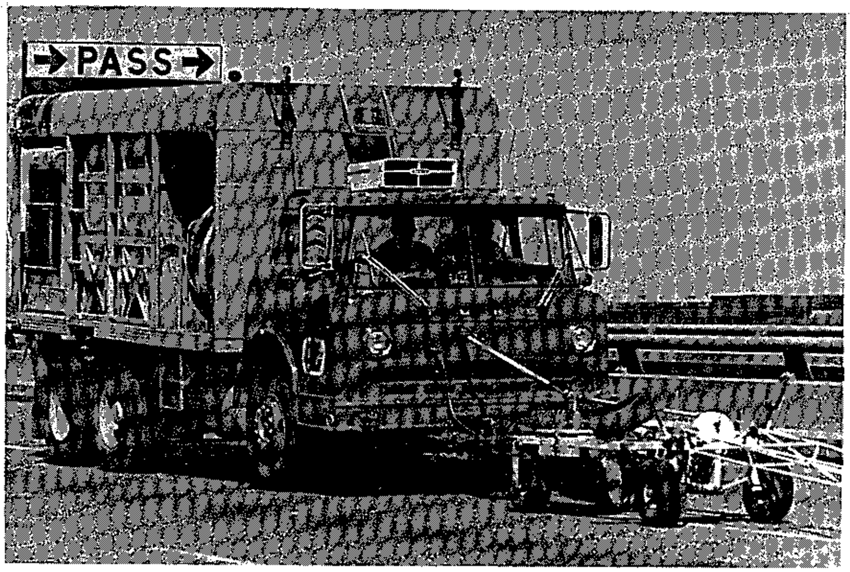
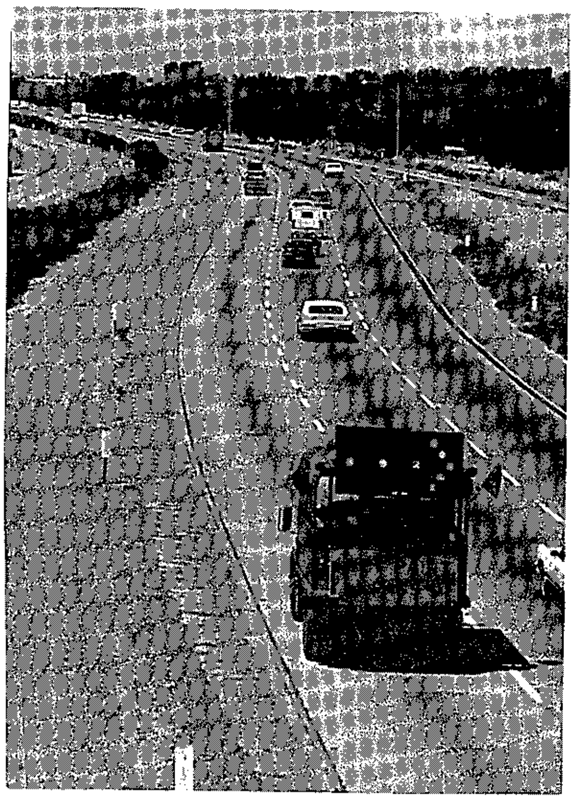


Hot striper working in traffic on Interstate 80,
Davis, California





Hot striper working in
traffic, Interstate 80,
Davis, Cal. Note absence
of cones and lane closures.



INTRODUCTION

Heating traffic paint to speed the drying time is not a new concept. Many heating systems have been developed and are still in use today. One of the first was used by the Oregon State Highway Department about 1955. This system consisted of two 3000-watt electrical heating elements and a waffle-shaped heat exchanger that was capable of heating 65 gallons of paint to 160°F in one hour. Many variations followed -- Michigan in 1964 was experimenting with hot paint, and in 1968 had equipment capable of heating paint to 165°F with a dry time of 90 seconds. Florida, in 1966, had a system with a dry time of 2 minutes, and in 1967 was using a 50-second system. By 1970 Florida had converted their stripers to heat paint to 180°-190°F, by circulating compressor and radiator hot water through three heat exchangers, to give a one minute dry system. New York and Texas, in 1969-70, also began using hot traffic paints by the heat exchange method utilizing hot water or propane fired boilers. The 3M Company experimentally introduced an instant set paint which was tried in California in 1966-67. This paint, high in solids with a putty-like consistency, was designed for use in the Company's custom-built striper truck. This unit heated the paint under a pressure of about 2500 psi to 350°F by a gasoline fired boiler. The applied paint dried to a no-track condition in 10 seconds. Unfortunately, fire and other safety hazards were considered too great and the system was not adopted for use in California.

New Equipment

In 1972 the California Department of Transportation Equipment Branch designed and manufactured 11 hot paint stripers. These stripers are capable of heating traffic paint up to 200°F by the direct conversion of mechanical energy to heat energy without the use of heat exchangers. This is accomplished by friction of turbulance generated by rotating vanes inside the heater. The paint heaters are integral parts of an assembly of many components and cost studies have never been determined for individual components. The heaters cost $1,200.00 each.

Energy requirements for all pumps, paint agitators, heat conversion units and controls are supplied by a 275 HP diesel engine, which drives the various hydraulic motors. Cold paint is pumped by gear pump from storage tanks on the striper to the energy converter which then heats the paint to a preset temperature up to a continuous operating temperature of 200°F. The RPM of the heat converter is precisely regulated by a hydraulic fluid proportioner operating from a preset electronic temperature selector and controller. Both the preset temperature and the actual heater temperature are displayed as a digital readout. This heating system is capable of raising 50°F paint to 200°F in about 5 minutes and can hold the preset temperature within ±1°F. After the initial heat-up period, cold paint can be continuously pumped through the heater at 6 gallons per minute and maintain the preset temperature. From the heating unit, the hot paint is fed to a high pressure two-stage piston pump which develops 1500 to 2000 psi and delivers the hot paint to an airless spray system. The spray units are mounted on retractable carriages on each side of the truck between the two axles. For centerline striping, especially on two-lane roads, a 4-wheeled detachable sulkey with bead and paint spray guns may be connected to the front end of the striper. Steering for the sulkey controls and other operating switches are controlled by an operator in the cab.

The paint guns are arranged in three banks so as to paint three adjacent lines at one time. The two outer banks have three paint guns and two bead guns each; the middle bank has one paint gun and one bead gun only. The middle bank is used for black paint.

Operation with one paint gun and one bead gun requires a striper speed of about 5 MPH to give a dry paint film thickness of 0.007 to 0.009-inch. With all three paint guns in operation, maximum striper speed is about 15 mph for a dry film paint thickness of 0.007 to 0.009-inch. The unit is capable of painting single white or yellow 4-inch wide solid lines, skip line, or double yellow-black. There is one energy converter and high pressure pump for the white or yellow paints, and a separate energy converter and high pressure pump for the black paint. When changing yellow or white colors, the units must be first flushed with solvent. This system has not been entirely satisfactory, especially when changing from yellow to white. The flushing operation is time consuming, and wasteful of both paint and solvent. Even after thorough cleaning, the white is usually tinted with enough yellow to produce a short section of cream colored stripe. One of the units has been equipped with a separate heater and high pressure pump for each color and has performed satisfactorly.

The Paint Problem

It was quickly apparent that a normal type 15 or 30 minute dry paint could not simply be heated to 200°F or more to obtain dry times in the 30-second range. Paint has to be formulated having fast solvent release characteristics together with fast evaporating solvents.

Some of the first paints used in the hot applied system were furnished by 3M Company, J. E. Bauer Company, and a modified version of State of Texas specification which was developed in cooperation with Hercules, Incorporated.

The behavior of these commercial traffic paints and the various State of California compositional specification paints finally developed will be described in detail. All of our paints are formulated to comply with Rule 66 of the Los Angeles Air Pollution Control District.

In conjunction with the hot applied rapid drying paint, Caltrans Laboratory developed a faster drying cold applied traffic paint for use in the older, air-atomized stripers to speed up the dry time and minimize traffic delay. The behavior of these paints as well as commmercial products developed by J. E. Bauer Company will also be described.

CONCLUSIONS

1. Heating of traffic paint by the direct conversion of mechanical energy to heat energy has been shown to be a successful and safe operation. This system has eliminated the need for traffic control during the striping operation on multi-lane freeways as well as secondary roads, on both asphaltic and portland cement concrete type pavements.

2. Traffic paint for the hot applied rapid dry striper must be formulated using fast drying solvents and resins with good solvent release characteristics. Pigmentation must be designed to allow the paint film to "breathe" to hasten the drying time of the applied film.

3. As a guide for successful use in the hot stripers, the laboratory dry time of these paints must be around two minutes or less when tested cold by ASTM D-711. this does not necessarily guarantee a no-track time on the road of 30 seconds of less, but serves as a useful laboratory guideline. Any paint to be regarded as rapid drying must be road tested. This means applying the paint

at 200°F, at a rate to result in a dry film paint thickness of 0.007 to 0.008-inch. The paint must dry to a no-track condition in 30 seconds or less when a standard size passenger sedan is driven over the line in a normal simulated passing maneuver.

4. State of California compositional specifications for hot applied traffic paint have been developed and found to be satisfactory as to application properties and wear life. One commercial rapid dry paint produced by J. E. Bauer, Company, Los Angeles, has proved satisfactory for hot applied application. In general, the rapid dry hot applied traffic paints developed have shown satisfactory road wear service comparable to the older slow drying paints.

5. Glass bead retention with the hot applied rapid dry paints has been far from satisfactory. The initial bead retention has been lower and the service life retention has been poor. Revision of application methods have improved the initial bead retention, but shows only marginal improvement under traffic. It is not known at this time whether poor bead retention is the price that must be paid for rapid dry paint, or whether the system can be improved either by mechanical application methods or by paint reformulation.

6. A low viscosity fast dry cold applied paint has been developed for use in older air atomized stripers. This paint has shown excellent application properties and good initial and service life bead retention. The no-track dry time for this paint is five minutes and serves to decrease traffic control time especially during the cooler weather.

7. A laboratory method has been developed to determine the glass bead content and dry paint film thickness of the traffic stripe as applied to the road surface.

8. Formulas have been devised for calculating striping speeds required for various paint film thicknesses and other striping variables.

IMPLEMENTATION

The Maintenance Branch has adopted the rapid dry formulas, Pt143, Pt148 and Pt149 for use in the California Hot Striper. The fast dry formulas Pt225, Pt226 and Pt235 have also been adopted for use in the older air atomized striping units. Both types of paints have been in operational use over the past two years.

RAPID DRY TRAFFIC PAINTS

The following is a series of paint formulations which document the major steps in the development of rapid dry paints. The final formulas Pt143, Pt148 and Pt149 have been in use for 2 years.

No preference is given to any raw materials described. Trade names are used for brevity and are intended for an "or equal" meaning, and their use does not necessarily constitute endorsement by the California Department of Transportation.

1. <u>California Specifications 711-80-195, 711-80-198</u>

   a) <u>Composition and Physical Properties</u>

This formula is based on the State of Texas formula which was developed by their Research Department in cooperation with Hercules, Incorporated.

Formula	Lbs./100 Gallons Paint 711-80-195 (White)	711-80-198 (Yellow)
Alkyd Resin, 60% solids, Reichhold P666-60	131	128
Cholorowax 40 (Chlorinated Paraffin)	76	74
Parlon 20 (Chlorinated Rubber)	101	98
Methyl Amyl Acetate	35	35
Methyl Ethyl Ketone	263	266
6% Cobalt Naphthenate	1	1
24% Lead Naphthenate	2	2
Epichlorohydrin	3	3
Anti-skinning Agent	3 Max.	3 Max.
Anti-settling Agents	7 Max.	7 Max.
TiO_2, Rutile, 95%	202	25
Chrome Yellow Medium	---	197
Talc	177	172
Zinc Oxide	51	49
Vicron 45-3 (Calcium Carbonate)	152	197

Physical Properties		
Pigment Volume Concentration, %	47.4	49.3
Viscosity, KU at 77°F, Average	75	77
Hegman Grind, Average	4	4
Dry Time, ASTM D-711, Average	8 minutes	8 minutes
Flexibility, 1/2-inch mandrel, Federal Spec. TT-P-115D	Pass	Pass
Dry Opacity, Federal Std. 141, Method 4121	0.97	0.97
Reflectance, Federal Std. 141, Method 6121	84.0	62.0
Yellowness Index, Federal Std. 141, Method 6131	0.04	----
Falling Sand Abrasion, Federal Std. 141, Method 6191, Liters/mil	6.25	6.20

b) Road Application and Evaluation

This traffic paint, faster drying than the regular slow dry paint, was first used in the air atomized stripers and cold applied. When applied with the Wald striper, which recirculated hot water for paint heating at a temperature of 120°F, the drying time was about 6 to 8 minutes for a dry paint film thickness of 0.008-inch. This was one of the first traffic paints that showed improved dry time over the regular dry paint which had a dry time of 15 minutes to 30 minutes when applied at 50°F.

When the first hot striper was operational, this paint was heated at temperatures above 120°F, with little decrease in no-track time. Summary of no-track dry times are as follows:

Road Surface Temp., °F	Ambient Temp., °F	R.H. %	Paint Temp., °F	No-track, Minutes	Dry Film Paint Thickness, Inches
63	55	45	120	8	0.008
72	60	67	120	5	0.006
58	51	42	157	7	0.008
58	51	42	180	6	0.008

As seen from above data, this paint system, although certainly an improvement over the regular dry paint, could not approach the desired 30-second dry time.

Road inspection and transverse test stripes have shown this paint to have a definite chipping tendency. This is especially noted on transverse stripes applied over unpainted concrete.

2. California Specification Pt56A, Pt69 and Pt70

The following specifications were the results of our earliest attempts to formulate a faster drying heated paint specifically for the hot striper.

a) Composition and Physical Properties

Formula	Lbs./100 Gallons Paint Pt56A (White)	Pt69 (Yellow)	Pt70 (Black)
Velsicol Hydrocarbon Resin XL-30	15	15	15
PVO Conjugated Bodied Safflower Oil, Z4	18.5	18.5	18.5
Parlon, 10 Cps	122	122	122
Chlorowax 40	41.1	41.1	41.1
Propylene Oxide	1.8	1.8	1.8
Chevron 5° Hexane	105	105	105
Methyl Ethyl Ketone	202	202	202
Toluene	47.9	47.9	47.9
6% Cobalt Naphthenate	0.4	0.4	0.4
24% Lead Naphthenate	0.6	0.6	0.6
Anti-skinning agent	1.1	1.1	1.1
Anti-settling Agents, Maximum	7.0	7.0	7.0
TiO_2, Rutile, 95%	164	----	----
Talc	72.1	72.1	72.1
Celite 281	90.8	90.8	90.8
English Mica, C-1000	71.7	71.7	71.7
Vicron 45-3	235	235	235

	Lbs./100 Gallons Paint		
	Pt56A (White)	Pt69 (Yellow)	Pt70 (Black)
Copper Phthalocyanine	0.1 oz.	----	----
Chrome Yellow Medium	----	208	----
Carbon Black	----	----	70.0
<u>Physical Properties</u>			
Pigment Volume Concentration, %	58.7	58.7	58.7
Viscosity, KU at 77°F	70	70	76
Grind, Hegman	4	3	5
Dry Time, ASTM D-711, Minutes	1	1	1

b) <u>Road Application and Evaluation</u>

For initial work, 1000 gallons each of white and yellow, and 250 gallons of black were made by Andrew Brown Paint Company, Los Angeles. Although the ASTM D-711 dry time in the laboratory was one minute, on actual road application with the hot striper the paint temperature had to be increased to 235°F before a 30-second no-track time could be realized. Continuous operation at this temperature caused accelerated wear on pumps, seals, and nozzles. Vapor locks in the piping system appeared more readily when operating at high temperature. The best mechanical operation for the striper is at 200°F or lower. This paint was not considered satisfactory for a rapid dry application.

A summary of no-track dry times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time Seconds	Dry Film Paint Thickness, Inches
58	80	75	152	90	0.005
60	73	55	200	60	0.008
56	68	48	220	60	0.006
68	85	30	230	45	0.005
60	72	42	235	30	0.007

Satisfactory wear performance both on centerline, skip, and edge line application has been observed with this paint.

3. California Specification Pt89 (White)

The next formulation included among other changes, a higher chlorinated rubber content.

a) Composition and Physical Properties

Formula	Lbs./100 Gallons Paint
Parlon, 10 Cps	168
Chlorowax 40	56
Styrenated Alkyd Resin, Reichhold 13-655	120
Chevron, 5° Hexane	118
Methyl Ethyl Ketone	140
Anti-skinning Agent	2.3
6% Cobalt Naphthenate	0.3
Soya Lecithin	8.0
Epichlorohydrin	2.3

	Lbs./100 Gallons Paint
TiO_2, Rutile, 95%	205
Talc	235
Vicron 45-3	157

Physical Properties

Pigment Volume Concentration, %	47.1
Viscosity, KU at 77°F	95
Grind, Hegman	3
Flexibility, 1/2 inch mandrel, Federal Spec. TT-P-115D	Pass
Dry Time, ASTM D-711, seconds	45

b) Road Application and Evaluation

A 200-gallon batch of Pt89 was made by the Andrew Brown Co., Los Angeles for test application. When applied with the hot striper, application properties were satisfactory and pumping rate from the 55-gallon drums to the striper storage tanks was 20 gallons per minute, which is considered very good. But again too much heat was required to meet the 30-second dry criteria. Although better than the Pt56A, it was not considered satisfactory.

A summary of the no-track times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
58	68	40	150	60	0.008
58	68	40	200	60	0.008
58	68	40	210	45	0.008
58	68	40	220	30	0.008

A paint temperature of 220°F was required for a 30-second no-track time as compared to Pt56A at 235°F.

This paint was applied to edgeline striping on the coastal area around San Francisco and showed satisfactory wear qualities after one year of exposure.

4. California Specification Pt97, Pt98, Pt99

Finally, after further changes, the following formula was developed which was the first one used on an operational basis.

a) Composition and Physical Properties

Formula	Lbs./100 Gallons Paint Pt97 (White)	Pt98 (Yellow)	Pt99 (Black)
Reichhold Alkyd P666-60	97.5	99.0	119.6
Chlorowax 40	54.9	55.7	67.3
Parlon, 10 cps	164.5	167.1	201.9
Methyl Ethyl Ketone	136.2	138.4	167.2
Chevron, 5° Hexane	114.9	116.7	141.0
6% Cobalt Naphthenate	0.5	0.5	0.6
24% Lead Naphthenate	1.3	1.3	1.6
Epichlorohydrin	2.2	2.3	2.8
Anti-skinning Agent	2.2	2.3	2.8
Soya Lecithin	7.8	7.9	9.6
TiO			

	Lbs./100 Gallons Paint		
	Pt97 (White)	Pt98 (Yellow)	Pt99 (Black)
Vicron 45-3	153.3	141.2	50.2
Chrome Yellow	----	217.8	----
Carbon Black	----	----	71.8
Physical Properties			
ASTM Dry Time, D-711, Seconds	30	30	90
Nonvolatile, %	76.7	76.7	60.5
Viscosity, KU	100	102	90
Pigment Volume Concentration, %	52.3	50.8	26.3
Flexibility, 1/2-inch mandrel, Federal Spec. TT-P-115D	Pass	Pass	Pass
Sand Abrasion, Federal Spec. 141, Method 6191, Liters/mil	10	7	10
Taber Abrasion, 1000 cycles CS10 Wheels, 500 grs., Grams Loss	0.0365	0.0214	----

To improve the dry time, this system used a pure drying medium oil soybean alkyd for faster solvent release and added disto-maceous silica to the pigment for a more porous film to allow volatiles to more readily escape.

Some estimation of the relative drying rates of formulas Pt89 and Pt97, apart from the ASTM wheel, were made by drawing down a 15 mil wet film on glass. Peeling back part of the surface film at timed intervals shows that the Pt89 shows a dull or nonwet appearance under the surface film in 4 minutes. Yet both paints give an ASTM dry time of 30-45 seconds. It appears that the ASTM method measures the time of surface skinning in this case and not a true indication of a film that will support a passing maneuver by an automobile. This has been verified in road tests where the traffic passing over the Pt89 film will produce a track on the adjacent road surface after 30 seconds and the Pt97 gives a no-track condition after 30 seconds, both paints applied at 200°F.

b) Road Application and Evaluation

Loading rate from 55-gallon drums to the striper tanks was a satisfactory, 18 gallons per minute.

This paint system was the first to be adopted on an operational basis in 1973.

A summary of the no-track times are as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time Seconds	Dry Paint Film Thickness, Inches
73	106	38	200	20	0.008
67	109	50	200	20	0.008
55	70	78	180	30	0.009
65	75	70	200	25	0.009
82	100	60	200	30	0.008

These figures are taken from actual road striping operations. The dry paint film thickness was determined from test panels taken during striping operations. The no-track dry time was determined by using a follow car making a passing maneuver over the freshly painted line and is defined as the time when the automobile tires do not lay down a paint smear on the road adjacent to the stripe.

These dry times are for a normally beaded line which averaged about 3 to 4 lbs. beads per gallon of paint on the road.

Satisfactory wear performance has been reported by striping crews both on high volume and secondary roads.

The next specification was designed to reduce the amount of methyl ethyl ketone which, during 1973, was in short supply. In Pt97, 20.3 gallons MEK were required for 100 gallons paint and in Pt122, only 6.5 gallons MEK per 100 gallons of paint were required.

5. California Specification Pt122 (White)

a) Composition and Physical Properties

Formula	Lbs./100 Gallons
Alkyd resin, Reichhold P 666-60	97.4
Chlorowax 40	54.9
Chevron 5° Hexane	70.6
Methylene Chloride	170.5
Methyl Ethyl Ketone	43.9
Parlon, 10 cps	164.5
6% Cobalt Naphthenate	0.5
24% Lead Naphthenate	1.3
Epichlorohydrin	2.2
Anti-skinning Agent	2.2
Soya Lecithin	7.8
TiO_2, Rutile, 95%	200.1
Diatomaceous Silica	97.4
Talc	229.8
Vicron 45-3	153.3

Physical Contents

Pigment Volume Concentration, %	52.2
Viscosity, KU at 77°F	95
Dry Time, ASTM D-711, Seconds	30

b) Road Application and Evaluation

A 200-gallon batch of Pt122 was made by Andrew Brown Company in Los Angeles, for initial testing in the hot striper. Pumping rate from 55-gallon drums to striper tanks was 17 gallons per minute. A summary of no-track dry times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
63	82	68	120	120	0.006
63	82	68	200	30	0.008
63	82	68	210	20	0.005
80	106	53	200	30	0.008
69	93	68	200	25	0.006

The application and no-track time of Pt122 was satisfactory but after five months of road service on edge line, the paint was chipping very badly. Also, initial bead retention at time of application was very poor; less than 2 lbs. beads/gallon on the line. This specification was not considered suitable for use. Although the Pt97 and Pt98 rapid dry paints performed satisfactorily in the hot striper, objections were voiced by some of the paint contract bidders on the use of 5° Hexane, with its very low flash point (-10°F) creating a hazard during manufacture. Chevron 225

Thinner (or equivalent) was substituted in another formulation, Pt143, Pt148 and Pt149 having a more reasonable flash point of 27°F (Tag Open-Cup), but having a slower evaporative rate than 5° Hexane. Slightly less MEK was also used in this formula. In response to material shortages and to reduce costs, TiO_2 was also decreased from 2 lbs./gallon to 1.5 lbs./gallon in Pt 143.

6. California Specifications Pt143, Pt148, Pt149

a) Composition and Physical Properties

Formula	Lbs./100 Gallons Pt143 (White)	Pt148 (Yellow)	Pt149 (Black)
Alkyd Resin, Reichhold P666-60	90.4	91.9	109.4
Chlorowax 40	57.7	58.6	69.8
Parlon, 10 cps	172.9	175.8	209.3
Methyl Ethyl Ketone	121.2	123.2	146.7
Chevron 225 Thinner	112.1	113.9	135.6
Toluene	45.2	45.9	54.7
6% Cobalt Naphthenate	0.5	0.5	0.5
24% Lead Naphthenate	1.2	1.2	1.4
Epichlorohydrin	2.1	2.1	2.5
Anti-skinning Agent	2.1	2.1	2.5
Soya Lecithin	7.2	7.4	8.8
TiO_2, Rutile, 95%	150	----	----
Chrome Yellow Medium	----	220.0	----
Carbon Black	----	----	65.3
Diatomaceous Silica	90.4	91.9	38.3
Talc	213.2	216.7	38.3
Vicron 45-3	169.0	122.1	45.9

Physical Properties	Lbs./100 Gallons		
Pigment Volume Concentration, %	50.4	48.7	24.7
Viscosity, KU at 77°F	94	97	80
Dry Time, ASTM D-711, Seconds	45	45	150
Dry Opacity, Federal Std. 141, No. 4121	0.90	0.91	----
Reflectance, Federal Std. 141, No. 6121	87	57.8	
Taber Abrasion, 1000 cycles, CS10 Wheel, 500 gr. weight, Grams loss	0.0186	0.0464	0.1550

b) Road Application and Evaluation

Loading rate from 55-gallon drums to the striper tanks was 18 gallons per minute.

Summary of no-track dry time is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
82	100	70	200	30	0.008
66	80	25	200	30	0.008
66	80	25	200	30	0.007
77	99	28	180	60	0.008

No-track time for this system is slightly greater than Pt97. Road application, storage stability, and service wear life have been satisfactory.

Durability of the Pt143 and Pt148 paints have shown excellent service life, on the average of at least 1 year depending on location and ADT. No adjustments in painting schedules have been necessary with the Rapid Dry paint as compared to the slower drying paints.

7. Raw Materials Costs State Specification Paints

During the start of the energy crisis, raw material costs and availability fluctuated rather unpredictably. Manufacture of paint was affected by the shortage of TiO_2 and most of the solvents were either in short supply or available only at increased prices. For comparison, the following is a list of the approximate raw material costs per gallon for Pt97, Pt98, Pt143, and Pt148 for 1972 and 1974:

	1972	1974
Pt97 (White)	$2.22	$3.32
Pt98 (Yellow)	2.70	3.87
Pt143 (White)	2.27	3.04
Pt148 (Yellow)	2.97	3.78

The smaller increase in cost of Pt143, compared to Pt97 is due in part to the lower TiO_2 content.

Our present State Specifications for Rapid Dry White and Yellow are Pt143 and Pt148 (January 1975). New formulas are being tested to reduce manufacturing costs, especially in view of the continued high prices of raw materials, and also with some formulas, to achieve a better balance between dry time and bead retention.

8. Commercial Rapid Dry Traffic Paints

a) 3M Company

Probably the fastest "drying" paint system produced to date was made by the 3M Company. Three paints were evaluated in California's new hot striper -- LGL 340 (white), LGL 341 (yellow), and LGL 425 (black). Composition of these paints is not known but they have high viscosities and solids and contain a suspended finely divided solid resin which melts on heating to produce a very fast drying paint.

Due to their high viscosity, loading rates from 55-gallon drums to the striper storage tanks were extremely low, about 1-1/2 to 2.0 gallons per minute. Constant mixing was required with a Lightning Propeller mixer to keep material loose enough to pump. This transfer rate was considered unaccepable from an operational standpoint. A summary of the no-track dry time is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
56	64	72	185	10	0.006
66	78	52	184	10	0.007
52	55	89	184	15	0.009
58	70	70	185	10	0.008
65	76	51	200	20	0.009

Road Application and Evaluation

Application properties of this paint system unfortunately proved extremely poor. When this paint was heated to 180°F or more, the finely divided solid resin melted and formed a low viscosity sprayable paint, but the paint had to be kept hot, meaning every orifice, valve, and line must also be hot since, on cooling, the paint formed a solid mass plugging the circulating system of the striper. Even during the striping operation, numerous down-times were encountered due to plugged lines. Of the 26 miles of test stripes applied over a 4-day period, 35 man hours were required to unplug lines, valves, orifices, and even the paint heater itself. This system was considered inoperable in Caltrans equipment and no further testing was done.

Although the 3M system presented very difficult operational problems, it represented a new concept in heated traffic paints which was of considerable value. Durability of the small test area of 3M paint was acceptable but not outstanding. One edge line application was made on State Route 92 near Half Moon Bay. The road is a 2-lane asphaltic pavement with many curves and grades. After three months of service, accelerated wear was observed in areas where large trucks on the downgrade curves swung out over the edge line in making the turns.

b) J. E. Bauer Company

The Bauer Company has produced a rapid dry traffic paint system suitable for the hot striper application. Although the formula for these paints is not known, some of the physical constants have been determined as follows:

	1364A9 (White)	1368A9 (Yellow)	1555A9 (Black)
Nonvolatile, %	79.3	74.9	66.0
Weight per gallon, Pounds	14.3	14.4	11.9
Pigment, %	63.7	64.0	47.4
Viscosity, KU at 77°F	95	95	71
Dry Time, ASTM D-711, Minutes	3	3	12
Grind, Hegman	2	2	2
Flexibility, 1/2 inch mandrel, TT-P-115D	Pass	Pass	Pass
Dry Opacity, Fed. Std. 141, Method 4121	0.99	0.98	----
Reflectance, Fed. Std. 141, Method 6121	85.5	67.0	----
Yellowness Index, Fed. Std. 141, Method 6131	0.09	----	----
Falling Sand Abrasion, Fed. Std. 141, Method 6191, Liters/mil	6.3	6.0	----
Taber Abrasion, 1000 cycles, CS10 Wheels, 500 gram weights, Grams loss	0.0356	0.0242	----

Loading rate from 55-gallon drum to striper storage tanks was 18 gallons per minute.

A summary of the no-track dry time is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
57	62	60	200	30	0.008
50	51	63	190	60	0.008
50	61	55	200	30	0.009
38	42	37	205	60	0.007
45	66	30	180	120	0.007
59	67	38	182	45	0.009
59	67	38	200	40	0.007
59	67	38	200	30	0.005
59	67	38	210	20	0.005
66	73	49	210	20	0.006
56	74	88	205	45	0.009
82	145*	49	205	25	0.006

*Hot AC laid just before striping.

At paint temperatures over 120°F, the Bauer system started to prematurely dry in the air as it came out of the spraygun forming "puffballs" of dry paint about 1/4-inch in diameter. This was undesirable since it deposited on the striper and the road surface. There is one interesting difference between Bauer paint and the State Specification paint (Pt97 - Pt143). The State specification paint does not form "puffballs" even when it is applied at temperatures of 235°F. One probable explanation is that the State specification paints have a much lower Pigment Volume Concentration.

Road service life for the Bauer paints has been acceptable for most areas observed.

c) Baltimore Paint and Chemical Company

A white, yellow, and black rapid dry hot applied system developed by B.P. & C.C. was tested on a trial basis in the hot striper. Again, composition was unknown but some of the physical constants have been determined as listed below. This was a special trial formulation made for us and to our knowledge does not represent their standard paints.

	TM 9198 (White)	TM 9199 (Yellow)	TM 9219 (Black)
Nonvolatile, %	72.0	73.0	70.3
Weight per gallon, Pounds	12.1	12.4	11.6
Pigment, %	58.0	59.1	55.7
Viscosity, KU at 77°F	114	115	108
Grind, Hegman	2	3	3
Dry Time, ASTM D-711, Minutes	1	1	2
Flexibility, 1/2-inch mandrel, TT-P-115-D	Pass	Pass	Pass
Dry Opacity, Fed. Std. 141, Method 4121	0.99	0.99	1.0
Reflectance, Fed. Std. 141, Method 6121	84.6	58.0	----
Yellowness Index, Fed. Std. 141, Method 6131	0.06	----	----
Falling Sand Abrasion, Fed. Std. 141, Method 6191, Liters/mil	6.7	6.7	6.7
Taber Abrasion, 1000 cycles, CS10 Wheels, 500 Grams weights, Grams loss	0.0234	0.0237	0.0279
Loading Rate, 55-gal. drums to Striper Tanks, Gallons per Minute	4	(high Viscosity)	

Gas Chromatograph analysis on all samples indicated toluene probably in excess of Los Angeles APCD Rule 66 (air pollution) limitations.

No-track dry times were very poor for a rapid dry, hot applied paint. One application on a freshly laid AC road surface in a very high traffic density area in Hayward, California (Intersection of State Route 92 and 185) was a complete failure. In this particular situation the road was opened to traffic right behind the hot striper with a follow car to keep traffic off for approximately 30 seconds. Traffic crossing the freshly painted line peeled up large sections of line making the area very unsightly.

The lanes had to be coned off, traffic rerouted, and the stripe repainted. In this case, even at an application temperature of 210°F and relatively high air and pavement temperatures, the no-track time was three minutes.

A summary of the no-track times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
70	130	50	200	90	0.007
83	122	40	190	60	0.004
79	105	31	190	90	0.009
79	105	31	190	90	0.008
76	125	40	150	240	0.008
76	125	40	210	180	0.008

On one application near Gilroy, California, on U.S. 101, during an edge line application, paint fumes and yellow dust from the yellow paint were so irritating that the operation had to be suspended. Yellow dust completely covered the outrigger guns and the truck chassis. Decreasing temperature from 190°F to 150°F alleviated the situation.

This paint system was not considered suitable for hot spray application and further testing was suspended.

d) Prismo Universal Corporation

A 20-mile section of Interstate 80 near Cisco Grove, California was striped with Nite Liner II, a proprietory brand of white rapid dry traffic paint made by Prismo Universal Corporation. Some physical constants were determined:

Nonvolatile, %	69.9
Lbs./Gallon	12.9
Pigment, %	49.9
Viscosity, KU at 77°F	95
Dry Time, ASTM D-711	3 minutes

No problems were encountered during application. A summary of the no-track times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Seconds	Dry Paint Film Thickness, Inches
48	59	48	140	90	0.006
			160	50	0.006
			180	30	0.006
			200	30	0.006

This system gave satisfactory application and good no-track times on a relatively cold road surface. Unfortunately, the application was made in March 1974 within the snowplow area. Subsequent snow removal operations and traffic destroyed the line.

9. Bead Retention of Rapid Dry Paints

We have encountered three major problems with the post applied pressurized bead system of the new hot striper.

1. Maximum bead application rate is about 5 lbs. beads/gallon of applied paint. This is a mechanical problem due to line restrictions and design of the beading system, and might be overcome, if necessary, by redesign.

2. Initial bead retention is about 70% at best.

3. Bead retention under traffic is very poor. A high percentage of the retained beads are lost from the line even before the paint shows any signs of wear.

In Item 1, when the Binks Model 21 bead guns are bypassed, the maximum bead flow rate was 47 lbs./minute at 100 psi air on the main bead storage tank demonstrating ample potential delivery rate to the guns. With one bead gun in the line, at 100 psi, this flow drops to about 5 to 6 lbs./minute. This situation can be improved mechanically. Binks has designed a bead gun that should vastly increase the bead delivery rate. Thus the problem in Item 1 can be solved relatively easily but Items 2 and 3 may be more difficult to overcome when dealing with rapid dry hot applied paints. The beads initially retained in the hot applied paint tend to "sit on top" of the paint film where they are easily dislodged by traffic. Ideally, the bead should be immersed to 60% of its diameter to provide good retention and long term reflectivity.

It would appear that prebeading the paint would solve the problems encountered with post-bead application. Although this method has never been tested in the California hot striper, the reasons for not doing so seem to outweight the possible advantages.

Abrasive action of a premixed beaded traffic paint on the piping and valve system of the hot striper is considered the most serious disadvantage. In the hot striper the paint is continuously recirculated through a small orifice valve to the heater. Excessive abrasive wear at this point would enlarge the orifice, causing pressure loss in the system. Excessive blockage at the valve, due to small beads packing at the orifice, would cause heat loss due to improper paint circulation and excessive pressure buildup which might eventually stall the high pressure pump or rupture a paint line. The same problems could occur at the paint gun orifices which are carbide tipped. They wear even when traffic paint is passed through them, but when prebeaded paint is used, the wear on the orifice tip would be accelerated. These opening in these tips are about 0.043-inch in diameter and the tips cost about $40 each.

In the traffic paint itself another problem would be encountered in keeping the beads in a uniform suspension, especially if the paint is stored for any period of time. The problem of keeping traffic paint pigments from settling in storage is considered to be enough of a manufacturing and formulating problem and the addition of glass beads would not improve the situation.

The most likely successful use for prebeaded paint relative to abrasion problem might be in the older stripers using relatively simple air atomized guns with larger orifices when the paint is cold applied by air pressure usually under 100 psi.

Initial bead reflectance of pre-beaded paint is low. Traffic, of course, exposes beads, and reflectance levels are then adequate. Initial reflectance might be improved by some additional drop on system for that purpose, but this would complicate the operation.

Plates 1 through 6 are on-the-road photographs taken of several rapid dry, beaded, hot-applied paints. The largest beads shown are approximately 0.016-inch diameter. The laboratory analysis of paint thickness and bead content are shown with each plate. The poor bead retention after two months of heavy traffic on Interstate 80 near Davis using Pt143, is shown on Plates 5 and 6. Numerous craters are evidences where beads have been dislodged by traffic. Plates 7 and 8 show slower drying paints and the much improved bead retention. Plate 7, the 80-195 (Texas) was applied with the hot striper at 140°F. The dry time was not rapid but the 86.8% initial bead retention was very good. The beads do not sit "on top" of the paint film but are recessed enough for good retention and yet provide immediate reflection. Another example is Plate 8 which shows the beaded paint film using the regular slow dry 80-95 applied cold with a Wald machine.

The California Hot Striper has continued to use the post applied pressurized bead application system with the hot applied rapid dry traffic paint and will continue to do so until a more retentive system can be developed, either by changing the paint formula or by mechanical means. Internal premix beads will not be considered for the Hot Striper use.

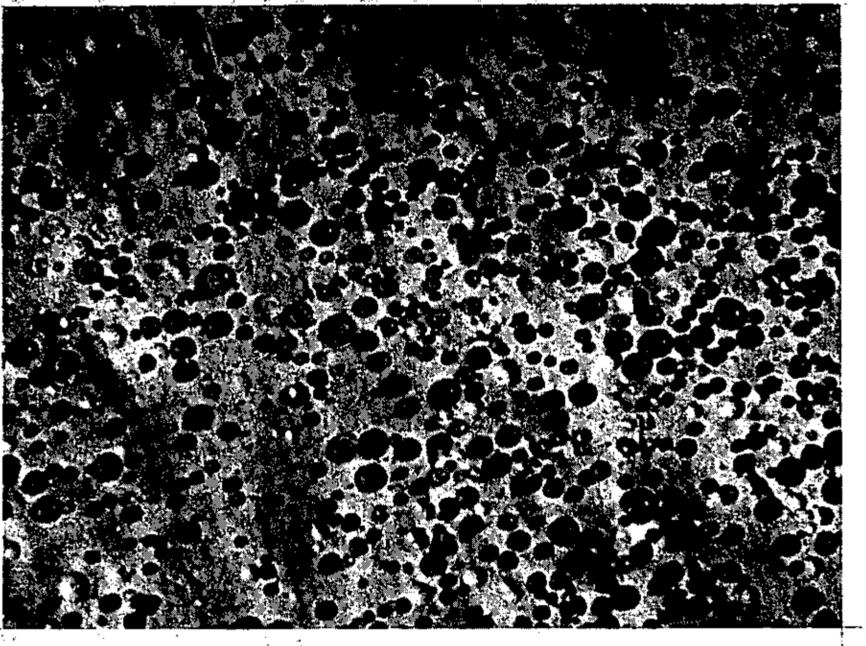


Plate 1. Pt 56-A. Paint thickness = 0.009 ins.
Lbs. beads/gal. paint = 5.2

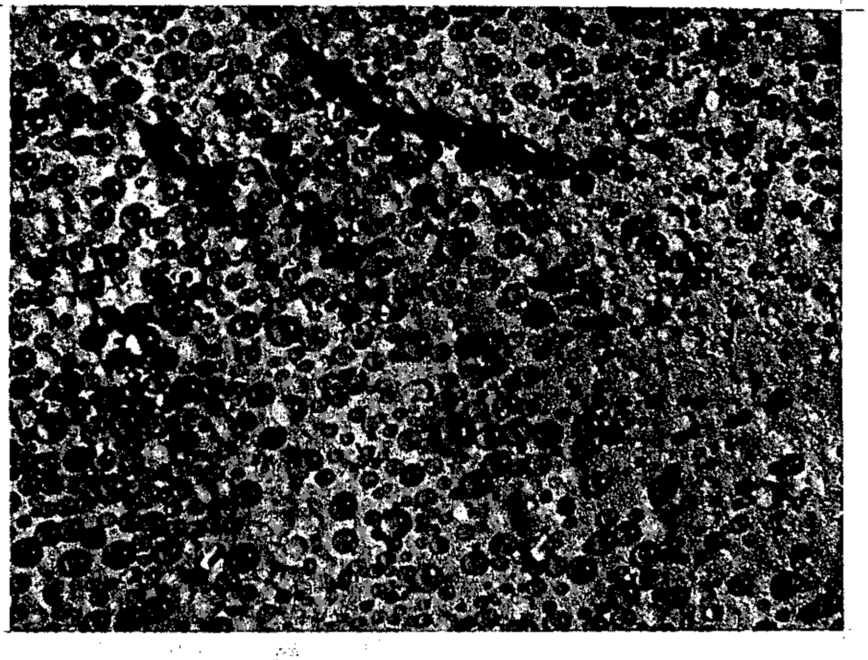


Plate 2. Pt 89. Paint thickness = 0.008 ins.
Lbs. beads/gal. paint = 4.2

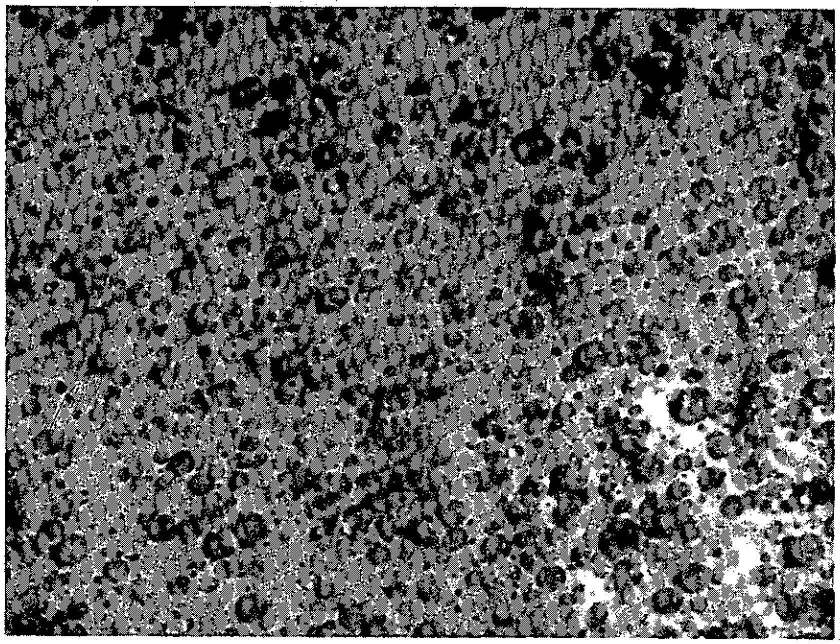


Plate 3. Pt 97.
Paint thickness = 0.008 ins.
Lbs. beads/gal. paint = 4.4

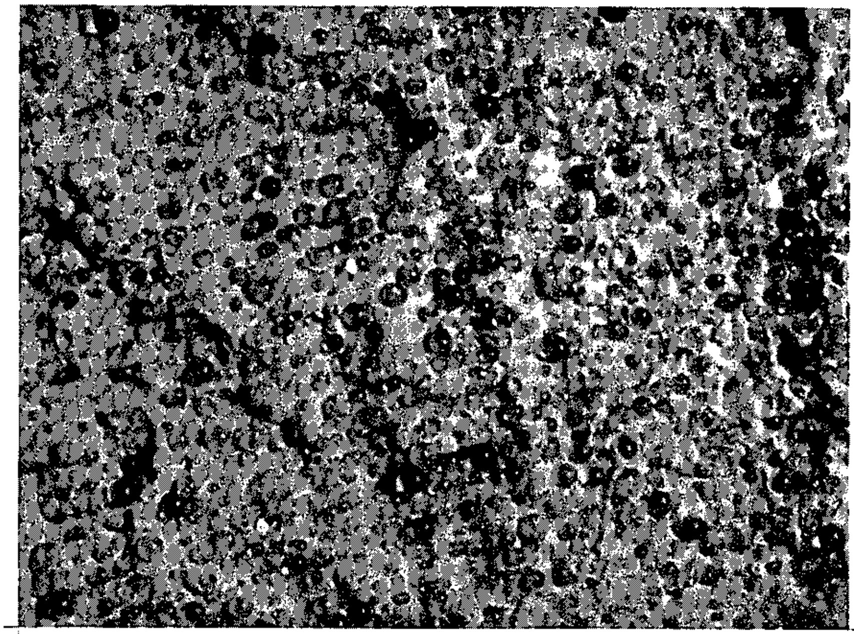


Plate 4. Bauer 1368A9
Paint thickness = 0.009 ins.
Lbs. beads/gal. paint = 3.5

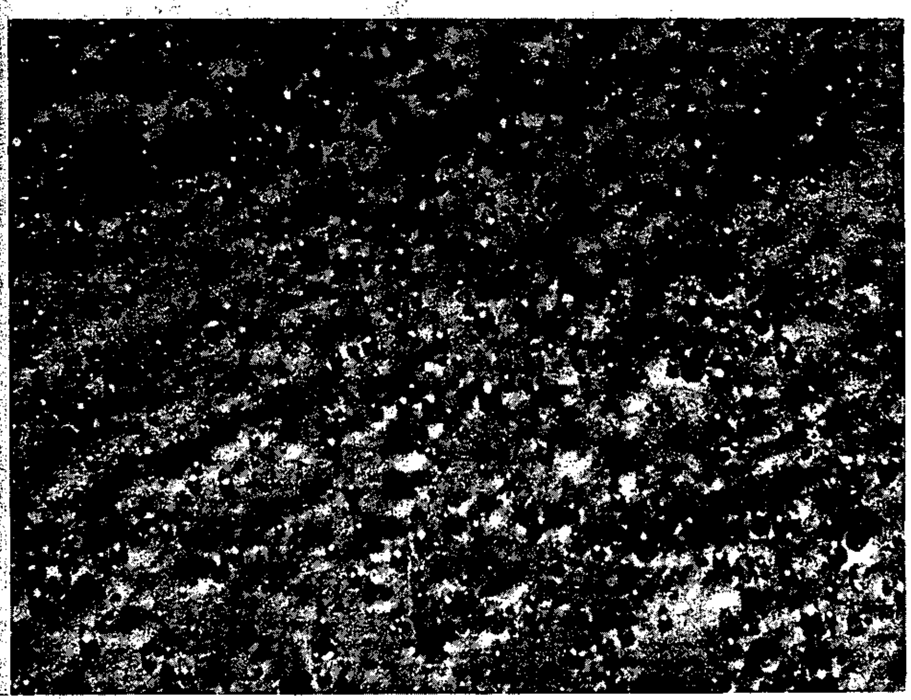


Plate 5. Pt 143
Paint thickness = 0.007 ins.
Lbs. beads/gal. paint = 4.4

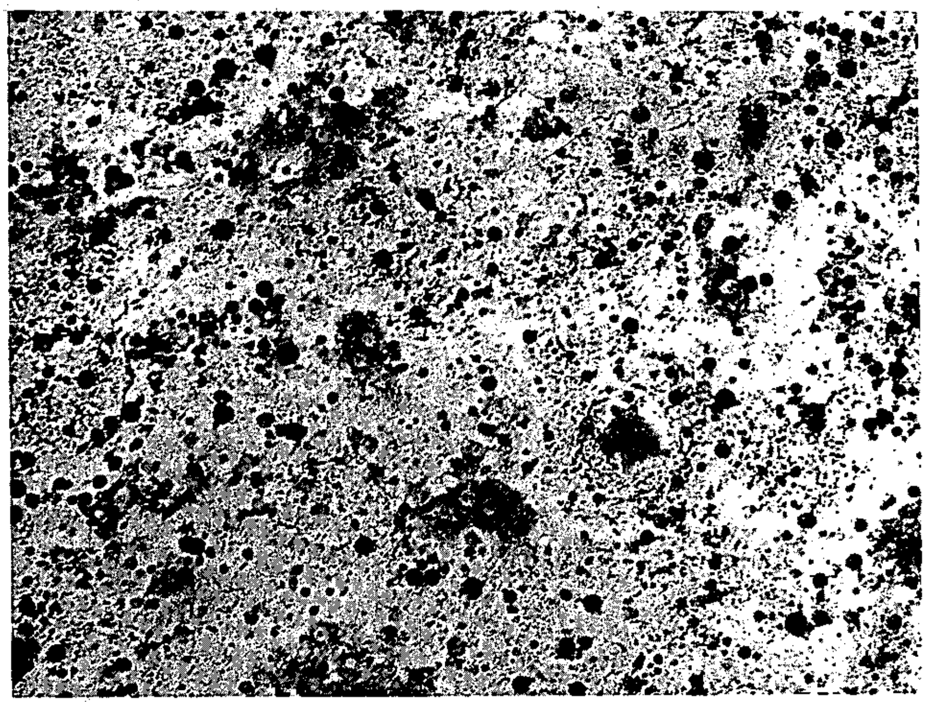


Plate 6. Pt 143.
After 2 months heavy traffic

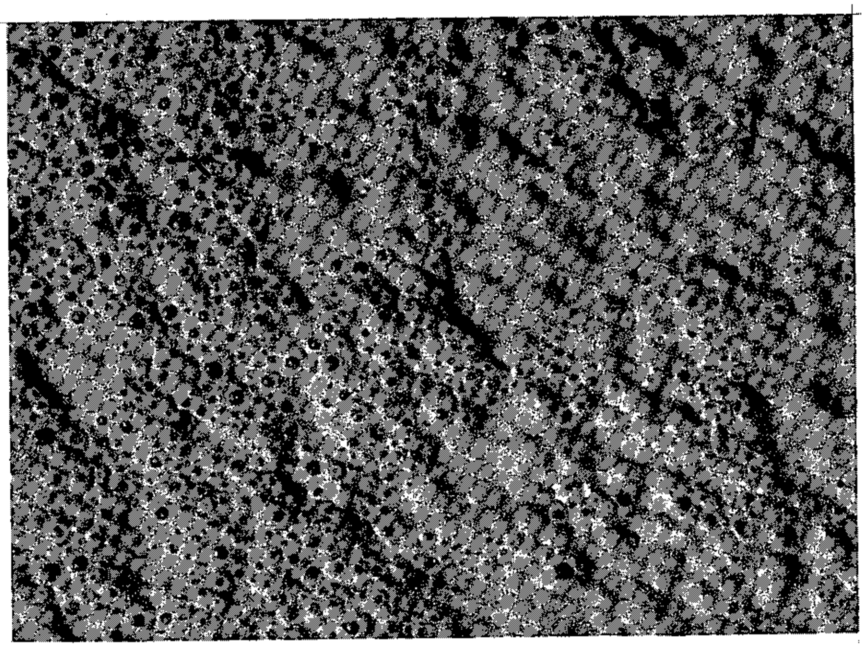


Plate 7. 711-80-195 (Texas)
Paint thickness = 0.010 ins.
Lbs. beads/gal. paint = 3.3
Cold applied with hot striper. Striper output = 3.8 lbs. beads /gal. paint.

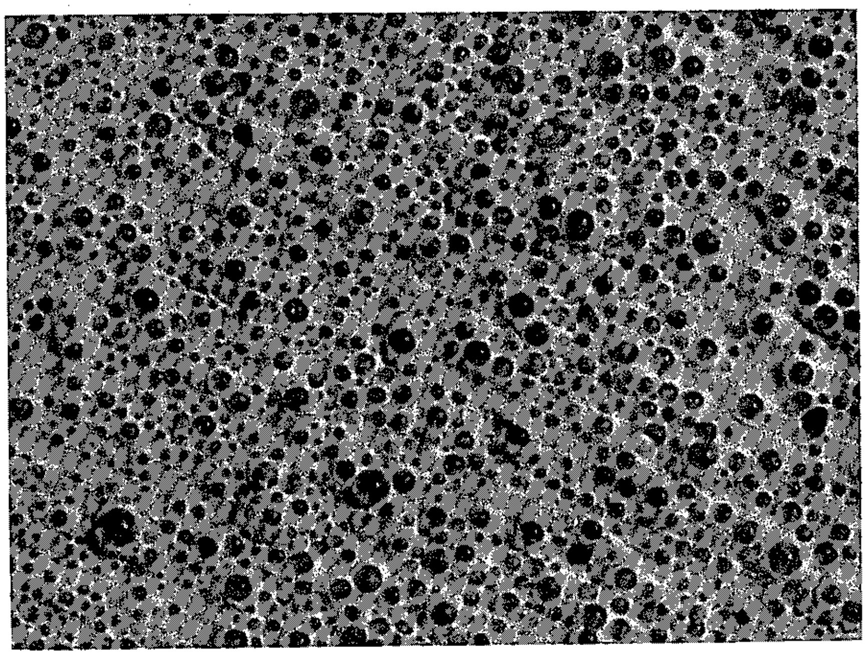


Plate 8. 711-80-95 (slow dry)
Paint thickness - 0.007 ins.
Lbs. beads/gal. paint = 5.2
Applied cold - Wald striper

A summary of average operational data relative to beading from California's hot striper operation is given as follows:

Paint	Beader Output, Lbs. Beads Per Gal. Paint	Initial Bead Retention on Traffic Line Lbs. Beads Per Gal. Paint	Percent Initial Retention
Calif. Pt56A, Pt69	4.4	3.2	72.7
" Pt89	5.2	3.2	61.5
" Pt97	4.8	3.5	72.9
" Pt122	4.7	1.8	38.3
Baltimore Paint & Chemical	5.0	3.5	70.0
711-80-195	3.8	3.2	84.2
711-80-198	5.0	4.0	80.0
J. E. Bauer Company	5.2	3.2	61.5
3M Company	5.8	2.6	44.8
Prismo, Nite Liner II	5.0	4.4	88.0

The slower drying Texas paints, 711-80-195 and 711-80-198, even though applied with the hot striper, exhibit high initial bead retention. The Pt122, a California specification with methylene chloride solvent, had very poor initial bead retention and yet the proprietary product by Prismo Nite Liner, also containing methylene chloride (but amount not known), showed very good initial bead retention.

FAST DRY TRAFFIC PAINTS

The rapid dry paint designed for 30-second drying time for use in the new hot striper was unsuitable for the existing fleet of older stripers having no heating capability and using air atomized paint guns. These units consisted of some commercial stripers, such as the Wald and Unimasco and other types of stripers built by the Caltrans Equipment Branch, but all employed air atomized paint delivery systems with a "drop-on" bead arrangement. To reduce the time needed to protect wet lines from traffic it was desired to speed up the dry time of the existing slow dry traffic paint. At the same time it was considered desirable to reduce the use of methyl ethyl ketone to a minimum due to the severe shortage of MEK and other solvents. The solvent shortage especially MEK was limiting the amount of traffic paint that could be made.

1. California Specifications Pt145, Pt146, Pt147

a) Composition and Physical Properties

Formula	Pt145 (White)	Pt146 (Yellow)	Pt147 (Black)
Alkyd Resin, P666-60	121.9	121.9	140.6
Chlorowax 40	27.4	27.4	31.6
Parlon 10 cps	82.3	82.3	94.9
Methyl Ethyl Ketone	73.2	73.2	84.4
Chevron 225 Thinner	182.2	182.2	210.1
Toluene	61.0	61.0	70.3
6% Cobalt Naphthenate	0.6	0.6	0.7
24% Lead Naphthenate	1.6	1.6	1.8
Epichlorohydrin	2.8	2.8	3.2

	Pt145 (White)	Pt146 (Yellow)	Pt147 (Black)
Anti-skinning Agent	2.8	2.8	3.2
Soya Lecithin	9.8	9.8	11.2
Talc	186.5	186.5	49.2
TiO_2, Rutile, 95%	150.0	----	----
Medium Chrome Yellow	----	240.0	----
Raven 1200 Furnace Black	----	----	84.4
Diatomaceous Silica, Celite 281	129.1	89.1	49.2
Vicron 45-3	142.8	142.8	59.1
Physical Properties			
Pigment Volume Concentration, %	57.8	57.8	38.5
Viscosity, KU at 77°F	66	66	66
ASTM Dry Time, D-711, minutes	3	3	3
Flexibility, 1/2 inch mandrel, TT-P-115D	Pass	Pass	Pass
Dry Opacity, Fed. Standard 141, Method 4121	0.95	0.95	----
Reflectance, Fed. Standard 141, Method 6121	87.0	59.0	----
Yellowness Index, Federal Std. 141, Method 6131	0.08	----	----
Tabor Abrasion, 1000 cycles, CS10 Wheels, 500 gram Weight, Grams loss	0.0914	0.0837	----

b) Road Application and Evaluation

The "fast dry" paints were used in the hot striper because of the unavailability of rapid dry paint at the time. No application problems were encountered with the fast dry paint applied through the hot stripers' airless system. The paint was heated to about 140°F, and dry times of about 1 to 2 minutes were obtained. Increasing the paint temperature caused dry spray and poor line quality due to feathered edges and premature drying. Best operation was at 140°F or lower since these paints were not designed for hot spray application at higher (200°F) temperatures.

The use of the air atomized cold applied striper units using a Binks 33 gun, No. 290 material nozzle, and a No. 46 air cap resulted in an erratic operation. Continuous adjustment of atomizing pressure with pot pressure was necessary to get any production. The paint dried in the atomizing nozzle inside the gun (internal air mix) causing stoppage, or a decrease in line width. Within a short distance, the 4-inch line width narrowed to 1 to 2 inches necessitating a stop to clean out the system. The fast dry and low solvency due to reduced MEK levels probably were the main factors causing premature drying.

A summary of the no-track dry times is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Minutes	Dry Paint Film Thickness, Inches
87	106	30	140	1	0.005 (hot striper)
57	76	32	60	2	0.006
82	110	35	80	3	0.009
91	120	30	83	3	0.008
72	104	50	70	3	0.005
58	56	76	50	4	0.006
87	125	40	80	2	0.004
60	76	90	60	2-1/2	0.008

Despite application problems no District complaints have been received concerning the road wear service of the Pt145 and Pt146.

c) Tests for Hard Dry Settling

Hard, dry settling was experienced with the first batches of the Pt145-Pt146. The settling was more pronounced when the paint was manufactured using high speed dispersion equipment rather than pebble mills. The formula was adjusted in cooperation with the vendors, Pervo Paint Company and Norris Paint Company, to incorporate about 6 pounds of Bentone 38 and 3 pounds of 95% methanol in 100 gallons paint. This adjustment corrected most of the hard, dry settling characteristics.

We have found one of the best ways to evaluate the settling tendencies of a paint is to ship a sample to a distant point via truck and return. We have shipped test samples from Sacramento, California to New Jersey and back, and have found this procedure will predict the settling characteristics in a relatively short time. Merely observing the paint in a container on a lab shelf is most unreliable and requires too long a time for settling to occur. We have tried accelerating settlement using a vibrating table (Syntron Jigger Model J-1A) and have found that about 3-4 days of vibrating will screen out any poorly suspended paint. A combination of vibration and heat cycling probably would accelerate the test and we intend to develop this further. The ASTM Test D-1309 has been used but is very tedious and time consuming, and the results are questionable.

2. California Specification Pt225, Pt226, Pt235

In order to slow down the drying rate of the Pt145-146-147 system, several changes were made in the formulations. Since the chlorinated rubber level probably has the most critical influence on the dry time, it was lowered from 82 lbs./100 gals. to 56 lbs./100 gals. in Pt225. To keep the vehicle solids high, chlorinated paraffin (70% Cl_2 solid resin) was added. The solvent system was changed from 225 thinner to the slower evaporating 250 thinner.

To prevent hard, dry settling in storage, Bentone 38 wetted with alcohol was used in laboratory formulations. In conjunction with lower TiO_2, Johns-Manville Micro-Cell T-70 was added as an extender for TiO_2. It was during the experiments to find a suitable TiO_2 extender that the Micro-Cell T-70 was first used, and it was found that deleting the calcined diatomaceous silica, Celite 281 or MW 27, and using the T-70 gave vastly improved anti-settling properties with or without Bentone 38. In short, the calcined diatomaceous silica was contributing to the settling problems in this formulation, so it was deleted entirely and the Micro Cell T-70 used.

a) Composition and Physical Properties

Formula	Lbs./100 Gals. Paint Pt225 (White)	Pt226 (Yellow)	Pt235 (Black)
Alkyd Resin, Reichhold P666-60	139.6	141.2	147.9
Chlorowax 40	55.9	56.5	59.2
Chlorowax 70	27.9	28.2	29.6
Parlon 20 Cps	55.9	56.5	59.2
Methyl Ethyl Ketone	97.7	98.8	103.5
Chevron 250 Thinner	139.6	141.2	147.9
Toluene	62.8	63.5	66.5
6% Cobalt Naphthenate	0.7	0.7	0.7
24% Lead Naphthenate	1.8	1.8	1.9
Epichlorohydrin	3.2	3.2	3.4

	Lbs./100 Gals. Paint		
	Pt225 (White)	Pt226 (Yellow)	Pt235 (Black)
Anti-skinning Agent	3.2	3.2	3.4
Bentone 38*	8.4	8.5	8.9
95% Methanol*	4.2	4.2	4.4
Soya Lecithin*	3.5	3.5	3.7
TiO_2, Rutile, 95%	100.0	----	----
Medium Chrome Yellow	----	200.0	----
Furnace Black, Raven 1200	----	----	40.0
Talc	185.1	169.4	100.0
Micro Cell T-70	54.5	55.1	----
Vicron 45-3	185.1	169.4	100.0
Celite 266	----	----	100.0
Physical Properties			
Pigment Volume Concentration, %	51.3	51.3	44.1
Viscosity, KU at 77°F	70	70	70
Flexibility, 1/2 inch mandrel, TT-P-115D	Pass	Pass	Pass
Dry Opacity	0.92	0.88	----
Reflectance	86	77	----
Yellowness Index	0.06	----	----
Dry Time, ASTM D-711, Minutes	5	5	6

*The specified amounts and materials used in each formula for achieving satisfactory pigment wetting and suspension, as described in General Provisions, may be varied or changed to suit the Vendor's method of manufacture. Paint made with any deviations in anti-settling or wetting agents shall still be required to conform to the characteristics of the finished paint as described in Specific Provisions.

On our most recent purchase contract for Pt225-226-235 (January 1975), we have dropped the medium chrome yellow requirement from 2.0 lbs./gal. to 1.3 lbs./gal. due to increasing prices of this prime pigment (up to 69¢/lb.), and also because recent weatherometer studies have shown that the dulling to a reddish color is more pronounced with the higher levels of chrome yellow.

All Purpose Black, Pt235

In all of our previous rapid dry and fast dry paint specifications, we have included a black using the same vehicle that was used for the white and yellow. From field observations, it was determined that a rapid dry black was not a real necessity since it is used only for a contrast color and is unbeaded and applied at about 3 mils dry thickness, usually between a double yellow line for no-pass zone or median lines. At this reduced film thickness, drying is so fast that vehicle tracking is no particular problem. A new black paint, Pt235 was formulated to serve for use in the hot striper as well as the cold stripers. The carbon black level was reduced considerably to alleviate the gelling tendencies of black traffic paint with high carbon levels.

b) Road Application and Evaluation

Application properties with air atomized guns have been most satisfactory. Field observations have shown no internal drying inside the guns and very good line application rates primarily due to the low viscosity (70 KU) of this system. Anti-settling properties have been excellent in 55-gallon drums examined in the field.

3. Commercial Fast Dry Traffic Paints

A fast dry traffic paint system produced by J. E. Bauer Company has been used in California's cold applied air atomized striper units during periods of paint shortages and other delays in obtaining State specification paints.

The formula is proprietary, but some physical constants have been determined:

	1612A9 (White)	1613A9 (Yellow)
Nonvolatile, %	71.2	73.4
Weight per gallon, lbs.	12.1	12.5
Pigment, %	53.0	55.1
Viscosity, KU at 77°F	77	76
Dry Time, ASTM D-711	4	4
Flexibility, 1/2 inch mandrel, TT-P-115D	Pass	Pass
Reflectance, Federal Std. 141, Method 6121	88.8	58.2
Dry Opacity, " " " , " 4121	0.90	0.90
Yellowness Index " " , " 6131	0.07	-----
Falling Sand Abrasion, " , " 6191, Liters/mil	11.7	16.7
Taber Abrasion, 1000 Cycles, CS10 Wheel, 500 grams weight Grams loss	0.0445	0.0393

A summary of the no-track dry times from road tests is as follows:

Ambient Temp., °F	Surface Temp., °F	R. H. %	Paint Temp., °F	No-track Time, Minutes	Dry Paint Film Thickness, Inches
83	115	35	85	4	0.007
100	122	25	110	6	0.007
95	115	26	115	6	0.007
100	120	25	105	5	0.005

No operational difficulties have been reported with this system. Paint flow, especially during colder weather, has been reported to be slower, probably due to the higher viscosity (77 KU) as compared with State specification material at an average of 70 KU. Road service life has been observed to be satisfactory.

4. Bead Retention of Fast Dry Systems

Bead retention of Pt225, Pt226 and Bauer 1612A9, and 1613A9, was considered acceptable. The Pt225 and Pt226 showed better retention than the Bauer formulations. The Pt145 and Pt146 can be considered as fair, not as good as the Pt225-226, but much better than any of the rapid dry, hot applied paints. The bead retention appears to be a function of the dry time, but most certainly other factors influence the adherence of glass spheres to a paint film, such as bead gradations, density, surface tension, and method of application. These variables need to be more closely investigated.

Plates 9, 10, and 11 show some of the bead positioning in various paint films. Pt226 is very comparable to the slow drying paints in bead retention. The Pt145 and Pt146 probably are still a little too fast in drying (3 minutes) to have bead holding qualities comparable to the Pt225 and Pt226.

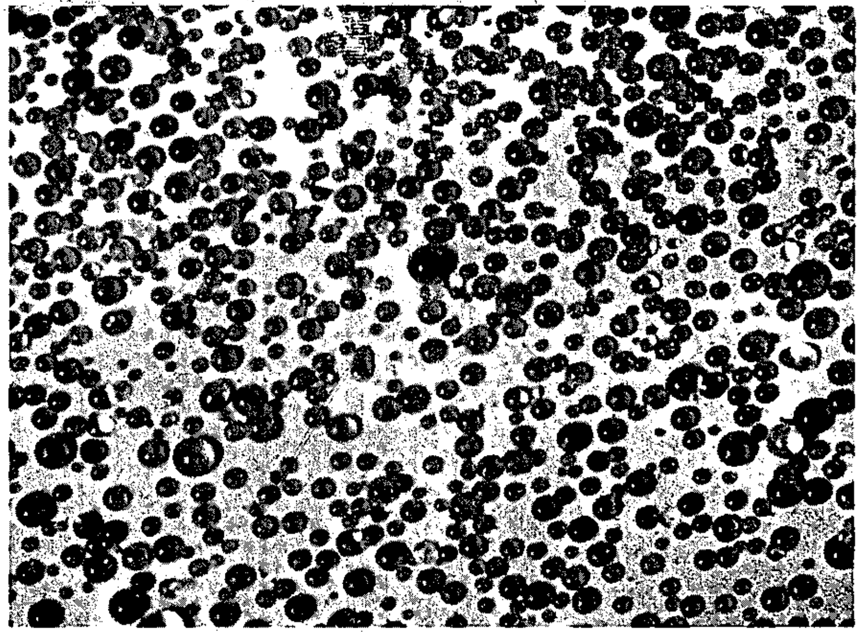


Plate 9. Pt 146
Paint thickness = 0.005 ins.
Lbs. beads/gal. paint = 5.6
Cold applied Contract Striper

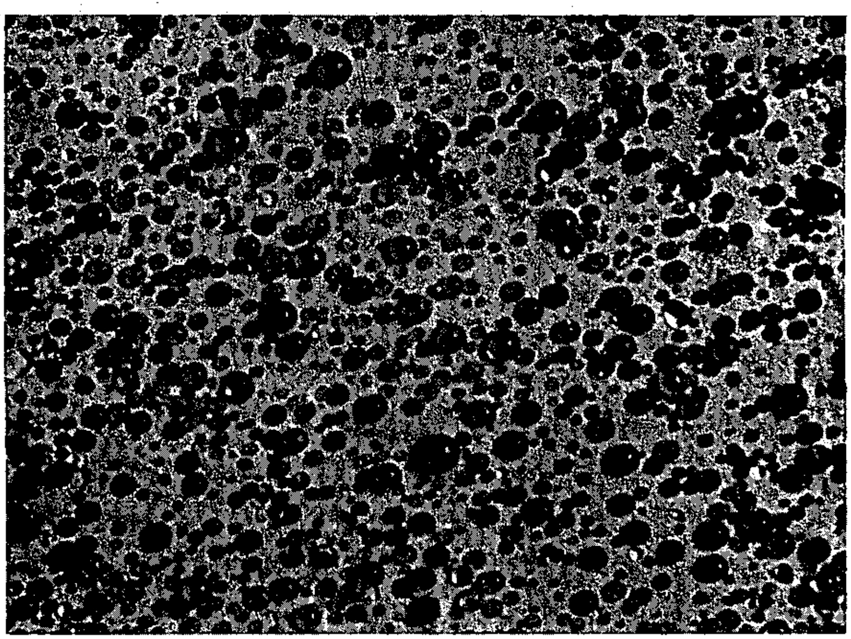


Plate 10. Bauer 1612A9.
Paint thickness = 0.007 ins.
Lbs. beads/gal. paint = 5.6
Cold applied Wald Striper

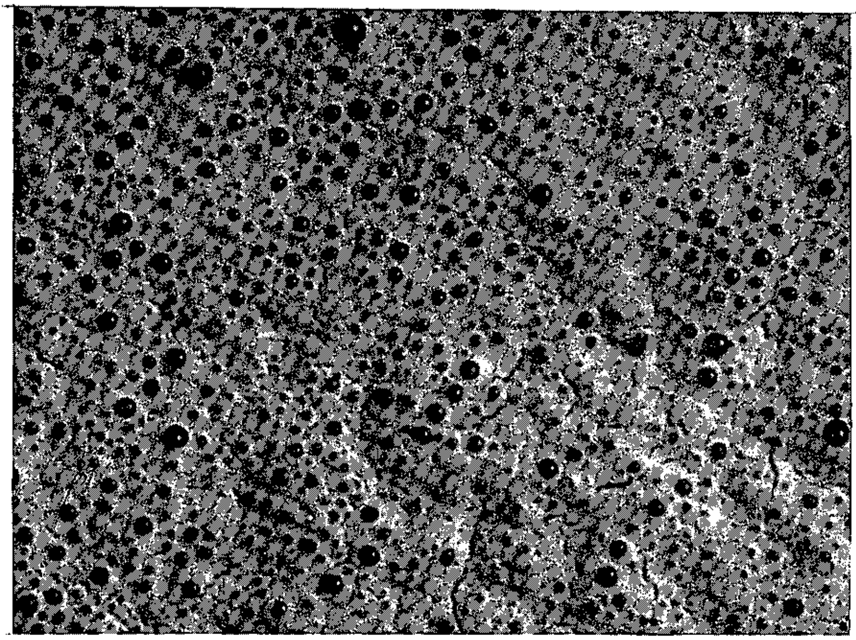


Plate 11. Pt 226.
Paint thickness = 0.008 ins.
Lbs. beads/gal. paint = 9.2
Cold applied Unimasco Striper

FIELD AND LABORATORY TESTING

1. Small Scale Hot Striper

In the design of hot applied rapid dry paints, the final criteria of the dry time is actual no-track time under field conditions. The ASTM D-711 dry time is a good laboratory method, but when dealing with 30-second dry times and heated paint, it is not very indicative of what will happen when the paint is applied with a striper unit.

To facilitate the laboratory testing of the hot applied paints, the Caltrans Equipment Branch designed and built a scaled-down model of California's Hot Striper. This small unit has a 5-gallon paint capacity and a Binks Model 41 airless pumping system operated by air pressure. The main power supply is a gasoline powered, air cooled Wisconsin V4 engine, driving a hydraulic system which supplies fluid power to the heater, and to the driving wheels for the striper. The unit has two air compressors in parallel to provide air for operation of the airless pump, pressure for the paint pot and pressure to operate the paint spray and bead guns, and an orifice valve. The unit has the same paint and bead guns that are used on the large hot striper, only smaller paint orifices are used. Cold paint is transferred to the heater by regulated air pressure, from the heater the hot paint goes to the paint pump developing about 1000 psi, and is then pumped to the spray head, and then returns to the heater. The paint flow is continuously circulated from heater to spray heads to heater to keep the paint hot.

Circulation is controlled by an air operated orifice valve in the return line from spray head to the heater. When paint is being sprayed, the orifice valve closes, temporarily blocking recirculation and when spray gun is off, the orifice valve opens to permit paint to be returned to heater. As in the fullscale striper, the RPM of the heater is controlled by a hydraulic fluid proportioner operating from a preset electronic temperature selector.

The paint spray gun, bead gun, and bead tank are mounted on a detachable frame which may be mounted in front of the striper or on one side as an outrigger. The unit can be driven at 1-1/2 mph while applying paint at a temperature of 200°F. For cross-striping purposes, the detachable frame can be mounted on a small 2-wheeled sulky, equipped with 20 feet of hose lines. For this use the striper is kept stationary and the sulky is pushed across the road surface. The paint film thickness is controlled by using a predetermined number of seconds to push the sulky across a 12-foot lane, or some other given distance.

This mini-hot striper has already proved its usefulness for evaluating new paint systems without the need for costly and time consuming full scale field trials using the truck mounted rig. Paint systems can be initially screened with the expenditure of as little as one gallon of paint. In one trial of a new hot applied paint made by 3M Company, it was quickly apparent that this paint would not likely work in the full size stripers even though the paint had reasonable properties when tested under conventional lab conditions.

Plate 12 shows the mini-hot striper operating at 1-1/2 mph and applying a traffic paint at 200°F. Plate 13 shows the sulky attachment being used to apply test stripes on Interstate 80 near Davis, California. A schematic diagram for the mini-hot striper is shown in Figure 1.

2. Transverse Test Stripes

a) Rapid Dry

Our original test location for transverse stripes was located on State Route 99, southbound near Florin Road. This is a 6-lane

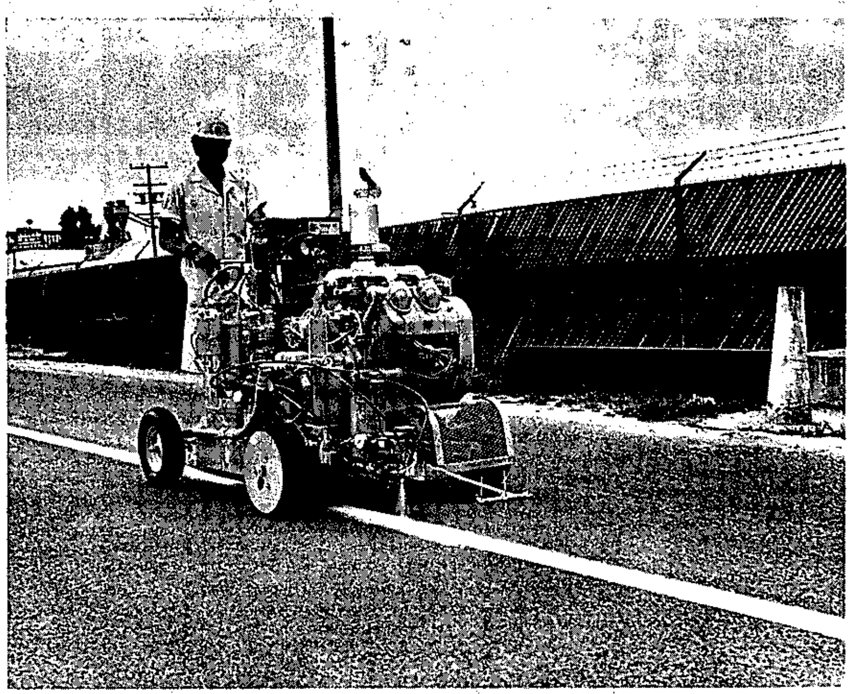


Plate 12

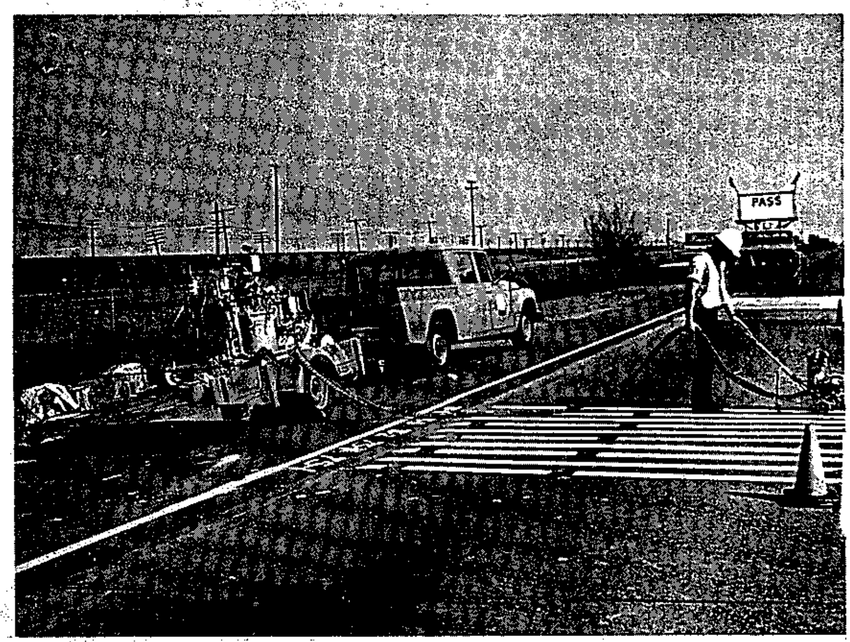
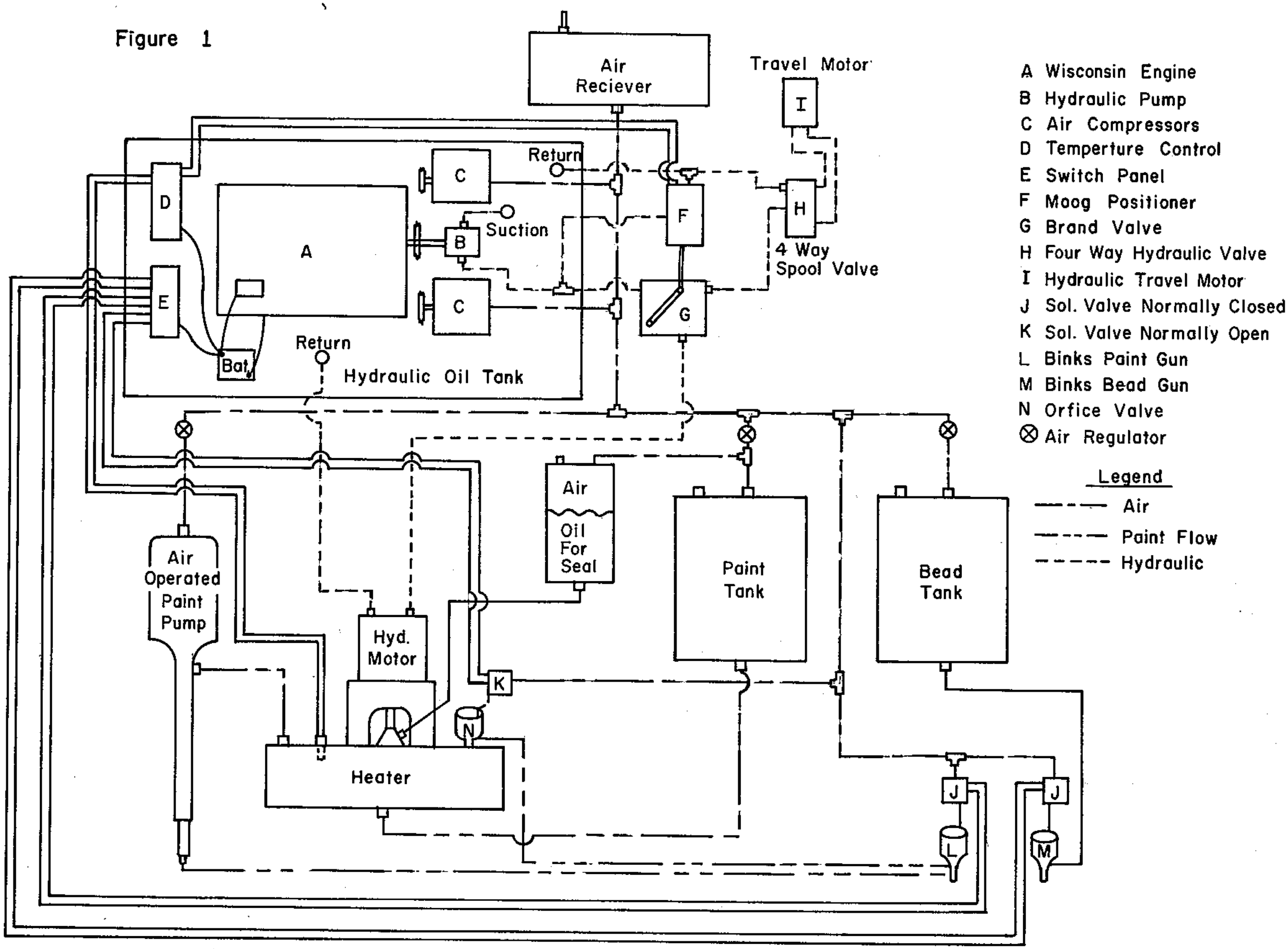


Plate 13

Figure 1



SCHEMATIC MINI HOT STRIPER

portland cement concrete freeway carrying heavy truck and passenger vehicles with an ADT of 60,000 in 1972. Unfortunately during the late summer when tomatoes are harvested in the Sacramento area, many trucks are used to transport tomatoes from the growing field to the processing plants. Tomato juice that leaks from these transports makes an unsightly black stain on the road and over the test stripe area making an evaluation during these periods very difficult. The tomato stain also can cause poor adhesion of the paint if stripes are applied during this period. When the fall rains start, the stain is washed off.

To avoid this situation, the test area was moved to a newly opened portion of U.S. 50 to the east of Sacramento. This area has a wide shoulder and ample room for maneuvering the striping apparatus and there are no tomato trucks. Unfortunately, the pavement in this area had a rather deep broomed texture parallel to the direction of traffic. Paint applied on the surface ran down to the bottom of the grooves, leaving a thin coating on the ridges. The paint film, of course, wears rapidly on the upper surfaces making evaluation of wear very difficult. We placed a series of rapid dry paints in this section, hot applied with the small scale striper, on May 8, 1974, and as of February 6, 1975, no wear is perceptible except on the crests of the textured surface, giving all lines a concrete grayish color. We have located a new test site on Interstate 80, westbound, near Davis, California. This area is worn smooth and carries a heavy traffic load. There is some tomato juice staining in the fall, but not as bad as State Route 99. We intend to repeat some of our previous Route 50 tests in this new area.

b) Fast Dry

On the State Route 99 test area, several fast dry paints were applied using a small air atomized paint applicator with a Binks

21 paint gun and drop-on bead application. Paint was applied at ambient temperature. This series was restricted to the faster drying paints; the regular 15 minutes dry 731-80-95 was included for comparison purposes only. Plate 14 shows service wear on beaded lines after 4 and 6 months exposure. It is apparent from the pictures that the 3-minute dry paint, Pt145, does equally well in service life as does the slower 15-minute dry (731-80-95). The Bauer 1612A9 paint performed satisfactorily also in these tests.

3. Accelerated Exposure Tests for TiO_2 and Chrome Yellow Levels

Recent shortages of TiO_2 and chrome yellow pigments as well as spiraling costs have led us to investigate the use of lower levels of these prime pigments in our white and yellow traffic paints.

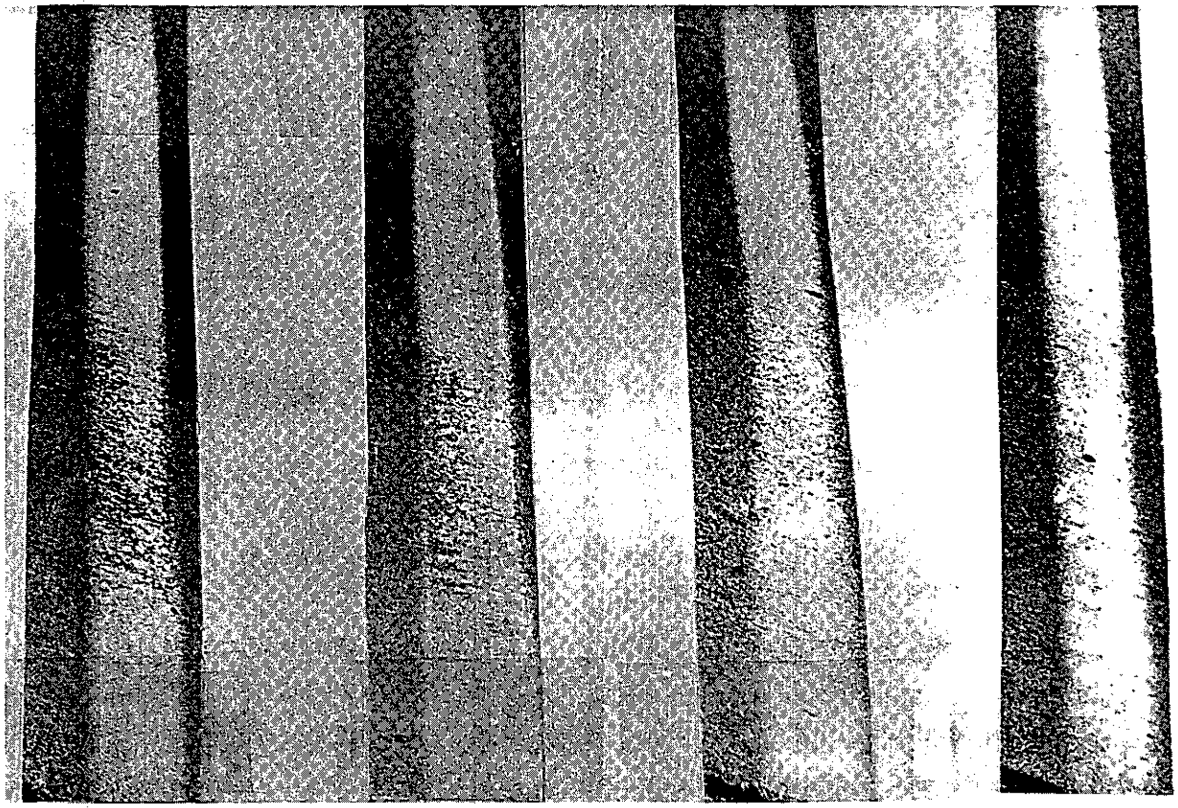
Paints containing various levels of TiO_2 and chrome yellow medium were drawn down on 1/16-inch thick aluminum sheet, 15 mils wet, allowed to dry two days, and trimmed to 3-inch by 9-inch size to fit in the Atlas Weatherometer Model 600 SW-WR. Cycling consisted of 102 minutes of Xenon light followed by 18 minutes of light and water spray. Samples were exposed for 350 hours. Reflectance readings made before and after exposure are as follows:

White Traffic

TiO_2, Lbs./100 Gals.	Reflectance Federal Std. 141, No. 6121 Green Filter		Percent Change
	Original	After 350 Hrs.	
150	87.0	84.6	-2.8
100	85.0	81.4	-4.2
50	83.0	79.6	-4.1
50	85.0	84.0	-1.2
50	86.5	85.4	-1.3

Plate 14

731-80-95 4 Months | 711-80-195 4 Months | Bauer 1612A9 4 Months | Pt 145 4Months



6 Months | 6 Months | 6 Months | 6 Months

Yellow Traffic

Chrome Yellow Medium, Lbs./100 Gals.	Reflectance Federal Std. 141, No. 6121 Amber Filter Original	After 350 Hrs.	Percent Change
220	80.0	44.4	-44.5
200	81.2	54.2	-33.3
100	81.3	58.4	-28.2
50	82.0	60.5	-26.2
50	82.3	63.0	-23.5
50	85.7	62.6	-27.0

These preliminary tests certainly indicate a downward adjustment in levels of TiO_2 and chrome yellow is possible without excessive sacrifice in reflectance. The "before and after" contrast of the 200-lb. chrome yellow was very noticeable. The 50 and 100-lb. levels of chrome yellow were much lighter and far less reddish and dull as seen by the less percent change in reflectance.

Visually, the high level of TiO_2 after exposure still looked lighter but only when compared side by side with the lower levels of TiO_2. Reflectance measurements did not indicate a great difference after exposure for all levels of TiO_2.

We intend to investigate the lower levels of these two prime pigments in further detail followed by road exposure in transverse stripes side by side so weathering changes can be observed under service conditions. No lowering of levels below those now specified will be made without thorough study.

COST COMPARISON OF RAPID AND FAST DRY PAINTS

1. Operating Costs

Operating costs including labor, equipment, materials and overhead for the hot applied Rapid Dry and the cold applied Fast Dry traffic paints are as follows for the California module of 9 ft of paint followed by 15 ft of unpainted surface or 1980 lineal feet of paint per lane mile.

	$/Mile 1973-74	$/Mile 1974-75
Cold Applied	75.51	80.53
Hot Applied	47.13	77.08

2. Bid Prices

Competitive bid prices per gallon in 55 gallon drums, delivered, for the Rapid and Fast Dry paints for several contracts are as follows:

	6-74	8-74	9-74	10-74	2-75
Pt143	$4.37	$4.56	$4.16		
Pt148	4.87	5.32	4.90		
Pt225				$2.94	$3.21
Pt226				3.87	3.64

APPENDICES

APPENDIX A

STRIPING CALCULATIONS

The usual wet film thickness for the slower drying paints was 0.015 to 0.017-inch which could be conveniently measured with a suitable wet film thickness gauge. In the rapid drying paint, this becomes rather difficult and we measure film thickness in terms of the thickness of the dry film. California's present standard is from 0.007 inch to 0.009 inch (dry).

With all other factors constant, such as the paint pressure and temperature, the easiest and most responsive method to control line thickness is the striper speed. Knowing the paint output at operating conditions and the physical constants of the paint, the following formulas may be applied:

1. Striper Speed, mph $= \dfrac{abc}{27500\ W\ h_d\ d}$

2. Gallons Paint per Mile Solid Single Line $= \dfrac{27500\ W\ h_d\ d}{bc}$

To calculate paint requirements for skip line, the solid line figure would be multiplied by the appropriate module figure. For example, California's present module is 24 ft., i.e., a 9-ft. paint stripe and a 15-ft. gap, so the solid line gallonage would be multiplied by 9/24 or 0.375 to give paint required for the skip line.

3. Wet thickness, inches $= \dfrac{100\ h_d\ d}{bc}$

4. Dry thickness, inches = $\frac{h_w \, bc}{100 \, d}$

Where a = Paint flow, gallons per hour

b = Density, wet paint, lbs. per gallon

c = Nonvolatile, wet paint, % by weight

d = Density, dry paint, lbs. per gallon

h_w = Wet paint thickness, inches

h_d = Dry paint thickness, inches

W = Line width, inches

APPENDIX B

DETERMINATION OF DRY FILM THICKNESS AND GLASS BEAD CONTENT

Scope

The desired dry paint film thickness of a painted traffic stripe is from 0.007 to 0.009 inches and should contain approximately 6 pounds of glass spheres (beads), State Specification 721-80-34, per gallon of paint.

With the advent of the California Hot Striper and the use of new paint systems capable of drying in 30 seconds or less when applied at 200°F, it has become necessary to check the film thickness and glass bead retention of the traffic line in order to set the proper truck speed and glass bead delivery rate for the hot striper.

Sampling

Samples are taken in the field using a tin plate 16 inches by 6.5 inches by 0.007-inch wrapped in 0.003-inch thick Mylar sheet and placed on the roadway and taped in a position such that the striper passes over the plate perpendicular to the long dimension of the plate. Sample is then removed from the road and laid horizontally to dry for at least two days, care being taken not to disturb the entrapped beads.

Apparatus

1. Analytical balance capable of weighing to 0.001-gram.
2. Sieves, 100-mesh and 200-mesh, and bottom pan.
3. Suitable solvents to soften paint and wash through screens.

4. Brush, scissors, ruler measuring to 0.01 inches.
7. 250 ml glass beakers.
6. Aluminum foil.
7. Ventilated hood.

<u>Procedure</u>

1. Strip off the Mylar sheet from the tin plate.
2. With scissors, carefully cut away the excess Mylar sheet from the paint sample leaving an area approximately 4 inches by 6.5 inches of sample. Trim sample to a uniform width and length.
3. Measure length and width of sample to nearest 0.01 inch.
4. Weigh sample (paint and Mylar film) to nearest 0.001-gram.
5. Cut sample in half with scissors and place the two pieces in a 250 ml beaker.
6. Cover sample with acetone and seal top with aluminum foil.
7. Let stand until paint film softens.
   Note: This may take a few hours or longer depending on the paint resins. If necessary, samples may be heated <u>with care</u> to hasten softening.
8. In ventilated hood, with a small brush, loosen paint film from Mylar, seeing that all the glass beads are brushed into the beaker. Discard the cleaned Mylar film.
9. Arrange the sieves so that the 100-mesh is on top, then the 200-mesh, and the pan on the bottom.
10. Transfer the softened paint and beads from the beaker to the 100-mesh screen and wash the beaker with solvent (So-Cal or Toluene) until all the beads are transferred to the screen.
11. Brush the softened paint gently through the 100- and 200-mesh screens and wash with solvent until beads are clean.
12. Make a final wash with acetone.

13. Dry screens with a gentle flow of air, about 20 psi, or place in oven for 10 minutes.
14. Carefully brush dried beads from each screen and weigh to nearest 0.001-gram.

Calculations

1. The net weight of the paint plus beads sample is obtained by calculating the tare weight of the Mylar film by multiplying the area X 0.0684 and subtracting this from the gross weight of paint plus beads plus Mylar.
2. The weight of the dry paint is obtained by subtracting the weight of beads from the net weight of sample.
3. The average dry film paint thickness is found from the following:

$$t = \frac{W}{A} \times \frac{231}{453.6\ d}$$

Where t = thickness in inches
W = weight of paint
A = area of paint sample
d = density of dry paint in lbs. per gallon

4. Pounds of beads per pound of dry paint is found by dividing the weight of dry beads by the weight of dry paint.
5. Pounds of beads per gallon of wet paint is found from the following:

$$X = \frac{YNd}{100}$$

Where X = lbs. beads per gallon wet paint
Y = lbs. beads per pound dry paint
N = percent nonvolatile wet paint
d = density of wet paint in lbs. per gallon

An example of the determination of dry film thickness and glass bead content of a sample is shown for a white rapid dry paint, Pt97.

Constants

Nonvolatile Wet Paint = 76.7%
Density Wet Paint = 12.60 lbs./gal.
Density Dry Paint = 18.4 lbs./gal.

Sample Number	Length, Inches	Width, Inches	Area, Square Inch	Net Weight Sample, Grams	Weight Dry Beads, Grams	Weight Dry Paint	Dry Paint Thickness, Inches	Lbs. Beads per Lb. Dry Paint	Lbs. Beads per Gallon Wet Paint
119	6.35	3.90	24.77	10.700 1.690 9.010	1.672	9.010 1.672 7.338	0.008	0.23	2.2